

UNITED STATES PATENT APPLICATION

Title:

COMPILATION OF FRACTIONAL MEDIA CLIPS

Inventor:

Edward O. Clapper

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Prepared by:
Richard C. Calderwood
Reg. No. 35,468

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COMPILATION OF FRACTIONAL MEDIA CLIPS

Background of the Invention

Technical Field of the Invention

The present invention relates generally to reconstruction or repair of sequences of data. The illustrated embodiment is adapted for use on audio or video data.

Background Art

In the biological sciences, a new technique has been created, known as gene sequencing. Biological scientists are able to reconstruct a lengthy sequence of genes, using only fragments of those genes, by identifying matching sub-sequences in two or more fragments, and, based upon those matching sub-sequences, appending or concatenating the fragments (minus duplicative overlapping sub-sequences, of course).

Brief Description of the Drawings

The invention will be understood more fully from the detailed description given below and from the accompanying drawings of embodiments of the invention which, however, should not be taken to limit the invention to the specific embodiments described, but are for explanation and understanding only.

FIG. 1 shows one embodiment of a system constructed according to this invention.

FIGS. 2A-B show a heuristic example of a data sequence reconstruction according to this invention.

FIG. 3 shows a heuristic example of a data sequence repair according to this invention.

FIG. 4 shows one embodiment of a method of reconstruction.

FIG. 5 shows one embodiment of a method of repair.

FIG. 6 shows another embodiment of a method of repair.

Detailed Description

For simplicity of explanation and ease of comprehension, the invention will be explained in terms of a system for repairing or reconstructing audio or video blocks from audio or video clips. A “block” may be, for example, an audio song, an audio album, a television show, a movie, or other

such item, while a “clip” may be any subset of such, or, more particularly, any sequential data subset of such. The skilled reader will appreciate that this example is only for teaching purposes, and is not intended to limit the scope of the invention. For example, the invention may readily be applied to reconstructing or repairing computer data files, text documents, databases, spreadsheets, or any other thing which is represented by an ordered sequence of data. The invention will be explained in terms of digital data, but is readily employable in the repair or reconstruction of analog data items, as well.

FIG. 1 illustrates one embodiment of a system 10 such as may be constructed utilizing the principles of this invention. The system includes one or more data sources 12a-n which may suitably be coupled together over a network 14. The topology, signaling protocol, and so forth of the network are not particularly germane to the application of the invention, and thus will not be discussed; suffice it to say that the network could include one or more of point-to-point signaling, peer-to-peer computing, server-client networking, local area networking, wide area networking, cable, wireless, cellular, satellite, local storage, and so forth.

Each data source includes a communication interface appropriate for its particular connectivity to the network, and a content storage in which it may store data, which data may include blocks and/or clips.

The reconstructor or repairer 16 (which may, in some embodiments, itself be one of the data sources 12) includes a content storage for storing blocks and clips, and a suitable communication interface. In some embodiments, the reconstructor further includes a digital signal processor (DSP) for performing DSP operations upon the block and clips, a block manager, a clip overlap comparator, a clip indexer, and a clip compiler. In some embodiments, the DSP may be a dedicated DSP unit, while in others, it may be a general purpose processor equipped with software embodying the DSP functionality. The repairer may optionally also include a content decoder and a content encoder for converting e.g. between analog and digital formats, a level normalizer, an equalizer, and a variety of other content manipulation mechanisms represented herein by way of illustration as a timbre adjuster. The reader will appreciate that any one or more of these features may be implemented in hardware, software, firmware, control codes, and the like, or hybrids thereof. In various embodiments, various ones of them may be built using analog techniques, while in other embodiments, various ones of them may be built using digital techniques.

The reader will understand that the specific interconnections between these items need not necessarily be exactly as illustrated, and that the illustration is merely for teaching purposes. The

1 skilled engineer will readily identify many possible configurations suitable for a particular
2 application.

3 In some instances, the repairer may have in its storage or otherwise available to itself, a
4 sufficient supply of clips from which it may repair or reconstruct the block in question. In such
5 instances, the network and other data sources need not be present or utilized.

6 In some implementations, the apparatus may include a mechanism for enabling user
7 manipulation or customization of the process. In some such embodiments, this may be accomplished
8 via a graphical user interface, using conventional techniques.

9 FIGS. 2A and 2B illustrates a reconstruction operation which may be performed by the
10 invention. Please continue throughout this document to continue referring also to FIG. 1. For
11 purposes of illustration, dashed arrows in FIG. 2B illustrate the identification by the clip overlap
12 comparator of matching sub-clips, while the solid arrows illustrate the copying by the clip compiler
13 of clips to create larger or more correct clips.

14 It is desired to reconstruct an original block 20, such as a song, but the complete data
15 sequence representing the original block is not known to be suitably available from any one source.
16 However, the reconstructor has in its storage, or obtains from a data source 12a-n, a first clip 22
17 which is known or believed to be from the original block. This knowledge or belief may be based
18 upon external input, such as human intervention, or upon internal input such as data in the clip itself
19 (e.g. in the case of an MP3 clip, the song title and artist may be encoded in the clip).

20 The block manager specifies, based on this external or internal input, the block to be
21 reconstructed, and causes the clip indexer and clip compiler to begin building on this first clip 22.
22 The DSP, under control of the clip indexer and clip overlap comparator, begins hunting through the
23 various clips which are in the clip storage or which are received over the communication interface.
24 The reader will appreciate that these mechanisms may make use of any suitable DSP techniques or
25 other data calculation techniques. These techniques may generate data representative of various
26 features of the clips, such as, in the case of audio: melody, harmony, tempo, rhythm, frequency
27 spectrum, intonation, tonality, timbre, echo, discrete cosine transformation (DCT) of such, fast
28 Fourier transform (FFT) of such, and so forth; or in the case of video: color, frame size, frame rate,
29 motion, encoding technique, hue, intensity, saturation, white balance, encoding technique, DCT or
30 FFT of such, and so forth.

1 These techniques may be applied over a clip in its entirety, or they may be applied to
2 sub-clips of fixed or of variable size. These sub-clips are generally represented by the data pieces
3 labeled “A”, “B”, and so forth. The reader will understand that the value e.g. “A” may represent
4 either the actual data values (digital or analog) in that portion of the clip, or it may represent the
5 result of the DSP operation upon the actual data values, such as the DCT output or such as a hash or
6 cyclic redundancy check (CRC) value representing the actual data values.

7 The details of the clip indexer are well within the abilities of those of ordinary skill in the art,
8 and will not be recited at any great length herein. Suffice it to say that the clip indexer keeps track of
9 which clips are known, which clips are needed, and so forth, using any conventional mechanism such
10 as tables, linked lists, or other suitable means. The clips may be indexed or located based upon any
11 suitable parameter, such as a hash value, an offset into their overall block, their first few bytes’
12 values, a DSP output based on the first few seconds of the clip, or the like. The clip indexer may
13 index entire clips each as a whole, and/or it may keep track of sub-clips within them, as needed.

14 As illustrated in FIG. 2B, it may in some cases be possible to have a clip with one or more
15 sub-clips that contain garbage, illustrated by the poison symbol. For purposes of explanation, assume
16 for now that these are known bad data (although as will be seen in the discussion of FIG. 3, below,
17 that is not necessarily the case).

18 The DSP, under control of the clip indexer and clip overlap comparator, eventually locates a
19 second clip 24 which “matches” a portion of the first clip 22. In the case shown, it matches at both its
20 start (“CD”) and its end (“GH”). The clip compiler is thus able to replace the known bad portion of
21 the first clip between these matching points, by copying the “AB” from the first clip, the “CDEFGH”
22 of the second clip, and the “IJ” of the first clip, to a result clip 34. The DSP also finds a third clip 26
23 which matches another portion of the first clip, and the clip compiler is then able to continue
24 building the result clip 34, in similar fashion, continuing from “IJ” to “OP”.

25 The reconstructor also has access to a fourth clip 28, either in its storage or over its
26 communication link, which it knows from either internal or external input to relate to the original
27 block. It finds matching clip 30 which enables the repair of part, but not all of the known bad data in
28 the fourth clip 28. It also finds matching clip 32 which enables the repair of the rest of the bad data.
29 Note that, as illustrated, the clip 32 could not have been matched against the clip 28, without the
30 intervening repair per clip 30. The clips 28, 30, and 32 enable the creation of clip 36.

1 Finally, the clip overlap comparator is able to determine (based on the matching "OP"
2 sub-clips) that the clip compiler should combine clips 34 and 36 to create the reconstructed block 38.
3 The block manager may then file the reconstructed block away for future use.

4 The reader will appreciate that it is only for the sake of convenience in illustration that the
5 matches have been illustrated as matching over two adjacent sub-clips (such as "CD").

6 FIG. 3 illustrates use of the invention in repairing a block, as somewhat opposed to the
7 operation of FIG. 2 which more illustrates reconstruction of a block. The skilled reader will
8 appreciate that these techniques may readily be practiced in tandem, and that they are illustrated
9 separately merely for clarity of explanation.

10 The reconstructor, or in this case repairer, has access to a plurality of blocks 40-50, either in
11 its own storage or from other data sources over the network via its communication interface. In FIG.
12 3, the reader will appreciate that the poison symbol does not necessarily represent known-bad data,
13 nor necessarily even data that are the same as at the other poison symbols, even within the same
14 sub-clip location (column).

15 The clip comparator compares the blocks, and identifies locations at which they are different.
16 These locations are likely to contain errors in one or more of the blocks. Such errors might include,
17 for example, clicks, pops, scratches, dropouts, warping, lost bits, mastering errors, incomplete
18 transmissions, snow, broadcast saturation, data corruption, and so forth.

19 In many positions, such as "A" through "D", the blocks are in agreement, and the clip overlap
20 comparator, clip compiler, and DSP can simply copy those values into their respective positions in
21 the creation of a "golden" block 52. In this context, "copy" may mean the generation of a new set of
22 values, such as an average of the plural existing instances of each sub-clip. Or, it might literally be a
23 copying from one of the sub-clips.

24 In the "E" position, the DSP observes that five of the blocks agree on the value "E", but the
25 sixth (42) has different data. The DSP may thus select a value ("E") according to a majority of the
26 blocks, for inclusion in the golden block at that position.

27 The "J" position is meant here to illustrate the principle that the "position" of data need not
28 necessarily in all cases be restricted to a strict lineal offset from the start. In the illustrated case, the
29 "J" position of the block 44 is actually a different size than the sub-clips at the "J" position in the
30 other blocks. It may even be null, with zero length. However, the clip overlap comparator and clip
31 indexer will realize that the clips have matching values "HI" and "KL", and that only one of the clips

1 has a different quantity of data between those values, and that it is thus likely that that block 44
2 simply has an error. In this case, the value "J" present in the other clips will be included in the golden
3 block.

4 The "R" position is meant here to illustrate the principle that it is not necessary to have a
5 large majority decision, in order to determine a golden value. Three blocks 46, 48, and 50 contain
6 matching values "R", while the other blocks contain values other than "R" and which may differ
7 from each other. In this case, "R" is selected for inclusion in the golden block.

8 The "X" position is meant here to illustrate the principle that a decision may even be made
9 based upon a minority, or in the extreme case, upon a single block 42. In some cases, based upon
10 some known aspect of the nature of the type of block under repair, it may be known that certain
11 characteristics of data are expected and likely. For example, it may be known that the blocks contain
12 an English language text file. If the "X" position is different as between all the blocks, but only one
13 of those sub-clips (the one in block 42) contains text which passes an English spelling check, that
14 sub-clip may be selected with confidence. In fact, it may be thus selected even if two or more of the
15 other blocks' corresponding sub-clips match each other; in that case, the matching majority is simply
16 bogus data.

17 Other forms of context-sensitive selection rules may be employed by the DSP, clip compiler,
18 etc. For example, in the case of an audio recording, the DSP may make an analysis of the prior
19 sub-clip "W" and subsequent sub-clip "Y", to determine an expected general value or quality of the
20 sub-clip "X" in question. For example, if "W" and "Y" are determined to represent music having
21 large low-frequency content and a heavy beat, and only the block 42 has an "X" position content that
22 has large low-frequency content and a heavy beat, the clip compiler may select that sub-clip for
23 inclusion in the golden block.

24 FIG. 1 illustrates additional features which may optionally be employed in combination with
25 the mechanisms described above. In the typical case, where the various blocks are taken from
26 different external sources such as multiple data sources 12a-n, the blocks are likely to have been
27 created on different equipment. The blocks are therefore likely to have different quality and
28 characteristics that are dependent upon their source equipment as well as their source media. For
29 example, a first copy of a song may have been captured from a scratchy vinyl record (the media)
30 played on a slightly over-speed record player with a worn needle and a weak pre-amp onto a worn
31 cassette tape (the equipment). A second copy of the song may have been digitally captured from a

1 radio broadcast of a compact disc, while the disc jockey was speaking over part of the song. In
2 addition to the media-dependent differences (such as the clicks and pops from the scratches on the
3 record), these two blocks will have equipment-dependent differences (such as gain or volume,
4 frequency equalization shape, playback speed and duration, timbre, and so forth).

5 The level normalizer, equalizer, timbre adjuster, and DSP may be utilized to conform the
6 various blocks to each other or to some ideal, either in whole or in part. For example, in FIG. 3, if the
7 system determines that the first block 40 is the “best”, when the “X” sub-clip of block 42 is selected
8 for inclusion in the golden block, it may be desirable to match that “X” sub-clip to the frequency
9 equalization, timbre, volume level, etc. of the first block 40. This will prevent or at least reduce
10 distracting changes in the audio “character” as playback of the golden block enters and leaves
11 sub-clip “X”.

12 FIG. 4 illustrates one exemplary embodiment of a method for reconstructing a block. The
13 reconstructing data source gets (60) a first clip from its storage or via its communication interface. It
14 then gets (62) a second clip, and attempts (64), using its DSP mechanisms, to determine whether the
15 clips have any overlapping segments. If not, it returns to getting more clips to compare against the
16 first clip. But if there is a matching overlap, it determines (66) whether there is one (or more) bad
17 sub-clip in the first clip which can be replaced with better data from the other clip. If so, the bad
18 sub-clips are replaced (68). The good segments of the clips are appended or concatenated (70) to
19 create a larger or at least better clip. If (72) the reconstruction of the block is complete, the
20 reconstructed block is saved (74) for future use. Otherwise, operation returns to looking for
21 additional clips to compare against for further reconstruction. In many cases, the concatenated clips
22 will match against other clips which the first clip or even the intervening clips would not have
23 matched. By iterative attempts, the method builds an ever-improving reconstructed block, until the
24 block has been completely reconstructed or until no further matching clips are available.

25 The reader will appreciate that this is but one simplistic example, and that the skilled
26 engineer will be able, armed with this disclosure, to embody this invention in a variety of methods
27 having different decision criteria, different control flow, and different operations.

28 FIG. 5 illustrates one exemplary embodiment of a method for creating a golden block by
29 repairing one or more lesser-quality blocks. The reconstructing data source gets (80) two or more
30 blocks, variously from its storage and/or its communication interface. Sub-clips which are found to
31 be matching between the blocks are copied (82) to the golden block. A non-matching sub-clip is

1 found (84); that is, a sub-clip which has different values or lengths as between the various blocks. If
2 (86) the majority of the blocks are in agreement as to the content of that sub-clip, their version of the
3 sub-clip is copied (87) to the golden block. If (88) a missing sub-clip is detected in some blocks but
4 found in others, the found sub-clip is copied (89) to the golden block. In some applications, it may be
5 possible to identify (90) a “best” or most likely sub-clip based on the context of the overall block or
6 of the surrounding sub-clips, for example. In such case, that sub-clip is copied (91) to the golden
7 block. If (92) there are more defects, operation returns to finding the next such defect. Otherwise, the
8 golden block has been completely assembled, and can now be fixed (94) as to such characteristics as
9 timbre, recording level, and so forth, to make a more cohesive, pleasing whole out of the various
10 sub-clips which have come from various sources. Finally, the golden block is saved (96) for future
11 usage.

12 FIG. 6 illustrates another exemplary embodiment of a method for creating a golden block.
13 The example is given with reference to a song. The user or repairer publishes (100) a list of songs to
14 “gild” or, in other words, of which to create golden masters. In one mode, this may be a passive
15 publication such as by posting a list to a website. In another mode, it may be published using a
16 mechanism such as that of Napster or Scour or the like. In another mode, it may be “pushed” to
17 potential sources of copies or instances of the song. In one mode, the list is a textual list of, for
18 example, the song’s title, artist, album name, unique identification number, recording date, pressing
19 master identifier, record label, songwriter, recording venue, and/or other suitable information. In
20 another mode, it might be, for example, a hash value or digital signal processing result of some
21 computation or operation upon the content of the song or some portion thereof. For example, it might
22 be a DSP output representing the first five seconds of the recording.

23 After using the published list’s contents as appropriate (such as by searching computer
24 filenames for a matching string, or by performing similar DSP operations upon their locally stored
25 songs), one or more of these sources responds by sending their copies of the song, which are received
26 (102) by the repairer. In some embodiments, the repairer may be a local user’s computer. In other
27 embodiments, it may be a central agency such as Napster.

28 The repairer confirms (104) that the received song is in its list, and, if not, it discards (106)
29 the song. Alternatively, it might cache the song in case it is needed in the future. Alternatively, it
30 might simply add that song to its list.

1 The repairer analyzes (108) a next sub-clip of the song, such as by performing DSP
2 operations on it. If (110) this sub-clip is not better than corresponding sub-clips of
3 previously-analyzed instances of the song, it does not contribute to the “goldenness” of the master,
4 and is ignored, with operation returning to analysis of a next sub-clip.

5 If it is the best of the corresponding sub-clips seen so far, it will be used in creating or
6 improving the golden master. In order to create the most audibly pleasing golden version of the song,
7 it is desirable to conform (112) the sub-clip to the other sub-clips already in the master. This may
8 include, for example, level adjusting, timbre adjusting, equalizing, and so forth. Alternatively, the
9 golden master may be conformed as a unitary whole at some future point, such as when it has been
10 completed.

11 The newly-found best sub-clip is added (114) to the golden master. It may replace a
12 previously-found then-best sub-clip.

13 If (116) there are no more sub-clips in the instance of the song under analysis, the golden
14 master is complete and may be saved (118) and published. Otherwise, operation continues at the next
15 sub-block.

16 It is not strictly necessary that the method of FIG. 6 be performed a single song at a time, nor
17 even a single instance/copy of a song at a time. In many embodiments, it will be desirable to gather a
18 plurality of copies of a particular song before beginning operation, to create a best possible golden
19 master. For example, in order to reduce distortion and inaccuracy that might be introduced by
20 conforming individual sub-clips from a wide variety of copies of the song, it may be desirable to
21 identify one “best copy” of the song and use the other copies to fix sub-clips in that “best copy”, and
22 to perform all conformation operations (e.g. timbre, level, and equalization) against the other
23 sub-clips in the “best copy” rather than those in a constructed-on-the-fly golden master.

24 In some instances, it may be suitable to publish the list of songs by publishing sets of known
25 sub-clips. For example, referring again to FIG. 2, the repairer could broadcast “I have a clip
26 ABCD❌❌GHIJKL❌❌OP and I need to repair the ❌❌ portions” or “I have a clip ending in LMNOP
27 and need to continue building from the OP”. The other data sources may then go searching through
28 their storage for instances of “ABCD” or “CD<anything>GH” or “OP<anything>” or the like, and
29 may send the matching sequences to the repairer.

30 The reader will appreciate that the skilled engineer will be able to embody this invention in a
31 variety of such methods, having different decision criteria, different control flow, and different

1 operations. The example given is for illustration only, and is not limiting on the scope of the
2 invention.

3 While the invention has generally been illustrated in terms of the repair and reconstruction
4 being done at a single agent, the reader will appreciate that the invention may well be used in a
5 peer-to-peer or distributed computing environment. In some such embodiments, a portion of the clip
6 processing may be done at e.g. a client, and the remainder of the clip processing may be done at e.g.
7 a server. For example, a client could perform clip indexing, and leave the clip compilation to the
8 server. Alternatively, the client could perform clip indexing and compilation, and the server could
9 perform aggregation of a golden master, or inter-clip audio normalization, or the like.

10 The reader will further appreciate that various business models may be constructed around
11 and utilizing this invention. For example, consider the case of a record label which has lost one or
12 more master recordings in a fire. The only existing copies of this recording may be records purchased
13 by the public over several years, and now in various stages of decline. The record company might
14 post a reward for the member of the public who uploads the copy of the recording which makes the
15 largest contribution to the golden master, and may also offer free new copies made from the golden
16 master to all who uploaded copies.

17 Finally, the reader will appreciate that while, in some applications, the invention may make
18 use of digital signal processing techniques, other applications may make do without such techniques.
19 For example, the reconstruction or repair of text files may be done using only conventional digital
20 computing hardware, without a DSP.

21 The reader should appreciate that drawings showing methods, and the written descriptions
22 thereof, should also be understood to illustrate machine-accessible media having recorded, encoded,
23 or otherwise embodied therein instructions, functions, routines, control codes, firmware, software, or
24 the like, which, when accessed, read, executed, loaded into, or otherwise utilized by a machine, will
25 cause the machine to perform the illustrated methods. Such media may include, by way of illustration
26 only and not limitation: magnetic, optical, magneto-optical, or other storage mechanisms, fixed or
27 removable discs, drives, tapes, semiconductor memories, organic memories, CD-ROM, CD-R,
28 CD-RW, DVD-ROM, DVD-R, DVD-RW, Zip, floppy, cassette, reel-to-reel, or the like. They may
29 alternatively include down-the-wire, broadcast, or other delivery mechanisms such as Internet, local
30 area network, wide area network, wireless, cellular, cable, laser, satellite, microwave, or other
31 suitable carrier means, over which the instructions etc. may be delivered in the form of packets,

1 serial data, parallel data, or other suitable format. The machine may include, by way of illustration
2 only and not limitation: microprocessor, embedded controller, PLA, PAL, FPGA, ASIC, computer,
3 smart card, networking equipment, or any other machine, apparatus, system, or the like which is
4 adapted to perform functionality defined by such instructions or the like. Such drawings, written
5 descriptions, and corresponding claims may variously be understood as representing the instructions
6 etc. taken alone, the instructions etc. as organized in their particular packet/serial/parallel/etc. form,
7 and/or the instructions etc. together with their storage or carrier media.

8 The reader will further appreciate that such instructions etc. may be recorded or carried in
9 compressed, encrypted, or otherwise encoded format without departing from the scope of this patent,
10 even if the instructions etc. must be decrypted, decompressed, compiled, interpreted, or otherwise
11 manipulated prior to their execution or other utilization by the machine.

12 Reference in the specification to "an embodiment," "one embodiment," "some
13 embodiments," or "other embodiments" means that a particular feature, structure, or characteristic
14 described in connection with the embodiments is included in at least some embodiments, but not
15 necessarily all embodiments, of the invention. The various appearances "an embodiment," "one
16 embodiment," or "some embodiments" are not necessarily all referring to the same embodiments.

17 If the specification states a component, feature, structure, or characteristic "may", "might", or
18 "could" be included, that particular component, feature, structure, or characteristic is not required to
19 be included. If the specification or claim refers to "a" or "an" element, that does not mean there is
20 only one of the element. If the specification or claims refer to "an additional" element, that does not
21 preclude there being more than one of the additional element.

22 Those skilled in the art having the benefit of this disclosure will appreciate that many other
23 variations from the foregoing description and drawings may be made within the scope of the present
24 invention. Indeed, the invention is not limited to the details described above. Rather, it is the
25 following claims including any amendments thereto that define the scope of the invention.
26